COST AND PERFORMANCE REPORT

Pump and Treat of Contaminated Groundwater at the
Baird and McGuire Superfund Site
Holbrook, Massachusetts

September 1998

Prepared by:

U.S. Environmental Protection Agency
Office of Solid Waste and Emergency Response
Technology Innovation Office

SITE INFORMATION

Identifying Information

Baird and McGuire Superfund Site
Holbrook, Massachusetts

CERCLIS #: MAD001041987

ROD Date: September 30, 1986

Treatment Application

Type of action: Remedial

Period of operation: 1993 - Ongoing
(Data collected through February 1997)

Quantity of material treated during application: 80 million gallons of groundwater [9]

Background [5,6,7]

Historical Activity that Generated Contamination at the Site: Chemical mixing and batching operations

Corresponding SIC Code: 2841 (Soap and other detergents), 2879 (Pesticides and agricultural products), 2491 (Wood preserving)

Waste Management Practice That Contributed to Contamination: Surface impoundment/lagoon, hazardous materials storage, discharge to septic system, discharge to wetlands

Location: Holbrook, Massachusetts

Facility Operations:

- Baird and McGuire Inc. (BMI) conducted chemical mixing operations at this site from 1912 to 1983.
- Contamination of an on-site public drinking water well was first detected in 1982 by the Town of Holbrook. This well had to be abandoned after contamination was detected. In 1982, a citizen complaint of an oily substance in the Cochato River, which runs along the eastern property boundary, led to a DEQE inspection. This inspection revealed the following: the tank farm was not lined or diked; sewage waste, process waste, and surface water runoff were collected in an open cesspool; and a black oily substance was being discharged to on-site wetlands.
- On May 2, 1983, BMI's permit to store chemicals at the site was revoked by the Town of Holbrook. As a result, BMI was forced to cease operations.
- EPA-initiated two emergency removal actions in 1983 and 1985. During these emergency removals, a plume of volatile organic and base neutral/acid extractable compounds was identified in the groundwater beneath the site.
- BMI voluntarily implemented a series of remedial actions. These included: installing a catch basin near the tank farm; filling the cesspool with concrete; installing booms on the Cochato River; removing the wetlands discharge pipe; and constructing a clay dike around the creosote lagoon to prevent a release.
- The site was listed on the National Priorities List (NPL) in October 1982.
- An RI was conducted in 1984 and 1985. Contaminants identified in the groundwater included PAHs, halogenated and nonhalogenated organics, inorganics, and pesticides.
- Source removal actions at the site included excavation and on-site incineration of contaminated soils. These removal actions took place in 1983, 1985, and 1995 through 1997.

SITE INFORMATION (CONT.)

Background (Cont.)

Regulatory Context:

- Site activities are conducted under provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986 §121, and the National Contingency Plan (NCP), 40 CFR 300.
- A Record of Decision (ROD) was issued in September 1986.

Groundwater Remedy Selection:
The groundwater remedy initially selected for this site consisted of extraction and treatment through biological activated sludge. The treatment system has been modified, and the activated sludge tanks are currently used as air stripping units.

Site Logistics/Contacts

Site Lead: EPA

Remedial Project Manager:
Chet Janowski*
U.S. EPA Region I
John F. Kennedy Federal Building
One Congress Street
Boston, Massachusetts 02203
617-573-9623

State Contact:
Harish Panchol
Massachusetts DEQE
617-292-5716

Treatment System Vendor:
Metcalf & Eddy Services
Walsh Contracting
Barletta Engineering

Treatment System Operator:
Tim Beauchemin
U.S. Army Corps of Engineers
696 Virginia Road
Concord, MA 01742-2751
(978) 318-8616

*Indicates primary contact.

MATRIX DESCRIPTION

Matrix Identification

Type of Matrix Processed Through the Treatment System: Groundwater

Contaminant Characterization [5,6,7]

Primary Contaminant Groups: Halogenated and nonhalogenated volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), inorganics, and pesticides.

- Selected index contaminants at the BMI site include: arsenic, lead, BTEX, trans-1,2-dichloroethylene (trans-1,2-DCE), 4-methyl phenol, 2,4-dimethyl phenol, naphthalene, 2-methyl naphthalene, acenapthene, dibenzofuran, fluorene, phenanthrene, dieldrin, and chlordane. Attachment 1 provides a complete list of contaminants detected at the site. Maximum concentrations for individual contaminants are not provided in available documentation.

MATRIX DESCRIPTION (CONT.)

Contaminant Characterization (Cont.)

- Concentrations of contaminants at the site were greater than 10,000 µg/L for total SVOCs and greater than 1,000 µg/L for total VOCs.
- Figures 1 and 2 illustrate the contaminant contours detected in 1988 and 1995, respectively, for total VOCs.
- The areal extent of the initial plume was estimated to be more than 700,000 square feet and approximately 70 feet thick. Based on a standard porosity of 30%, the plume volume was estimated at 111 million gallons.
- A light nonaqueous phase liquid (LNAPL) has been observed in several on-site monitoring wells. The material was identified as an immiscible oily substance that floats on the water table in the 1985 RI.

Matrix Characteristics Affecting Treatment Costs or Performance

Hydrogeology [6,7]:

Four distinct hydrogeologic units have been identified beneath this site. They are:

Unit 1A	Stratified material consisting of silty sands, sand, and silt.
Unit 1B	Stratified material consisting of fine to medium, fine to course sand.
Unit 2	Unstratified glacial till.
Unit 3	Fractured bedrock.

Figure 3 shows an east-west cross-section through the site that depicts the hydrogeology of the site. The upper stratified units (Unit 1A and 1B) pinch out on the west side of the site. A bowl-shaped depression is formed by bedrock beneath the site. Shallow groundwater is found at 10 to 15 feet below ground surface. Groundwater discharges to the Cochato River along the eastern site boundary.

The toe of the plume has migrated beyond the river. However, it reached a stagnation point in 1988. Figure 4 shows the same east-west cross-section and depicts the vertical plume distribution as detected in 1985. Measured flow velocities indicate that groundwater in Units 1 and 2 can move between 50 and 500 feet per year.

MATRIX DESCRIPTION (CONT.)

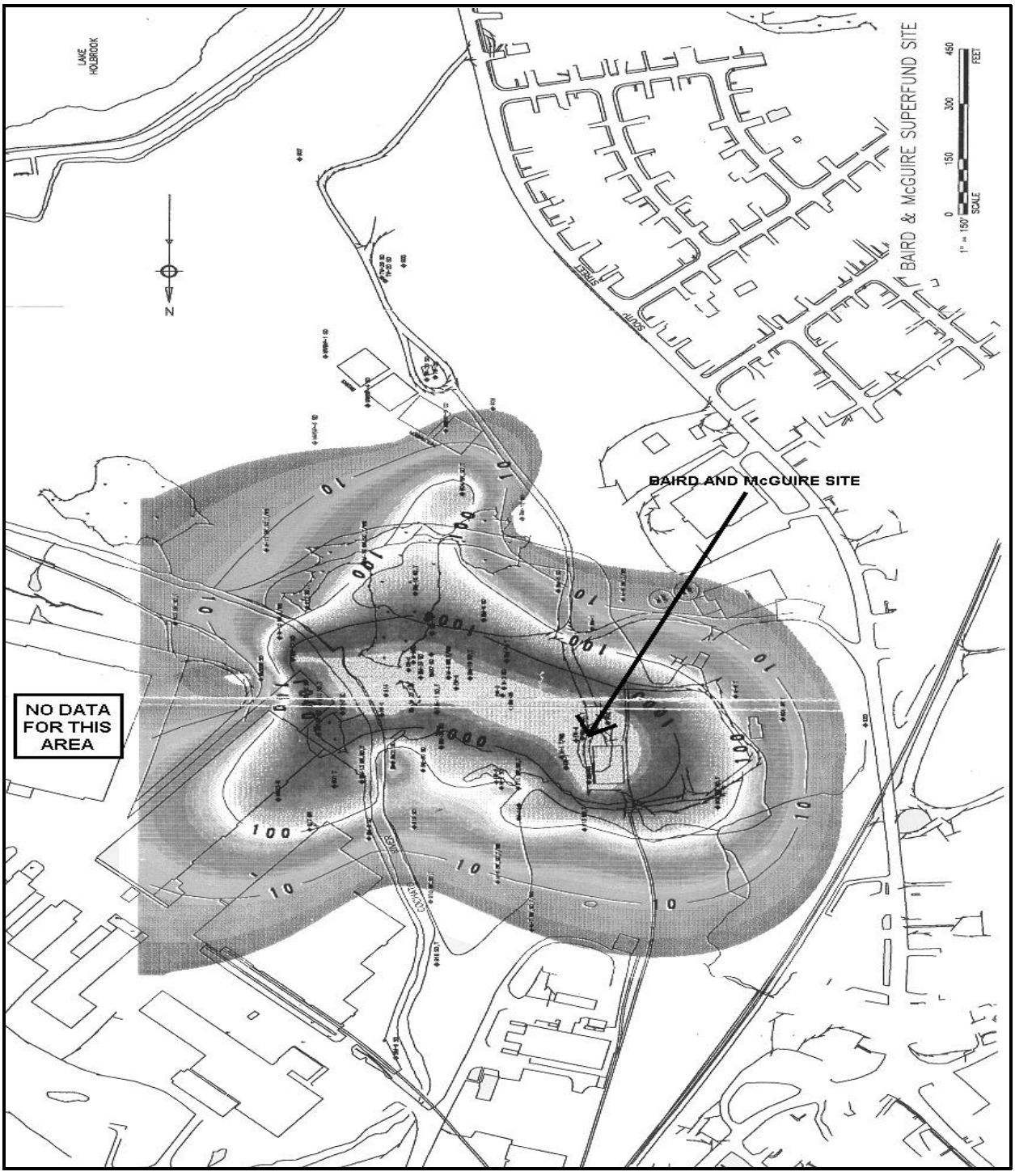

Figure 1. Total Volatile Organic Compounds, in µg/L (1988) (Best Copy Available) [8]

MATRIX DESCRIPTION (CONT.)

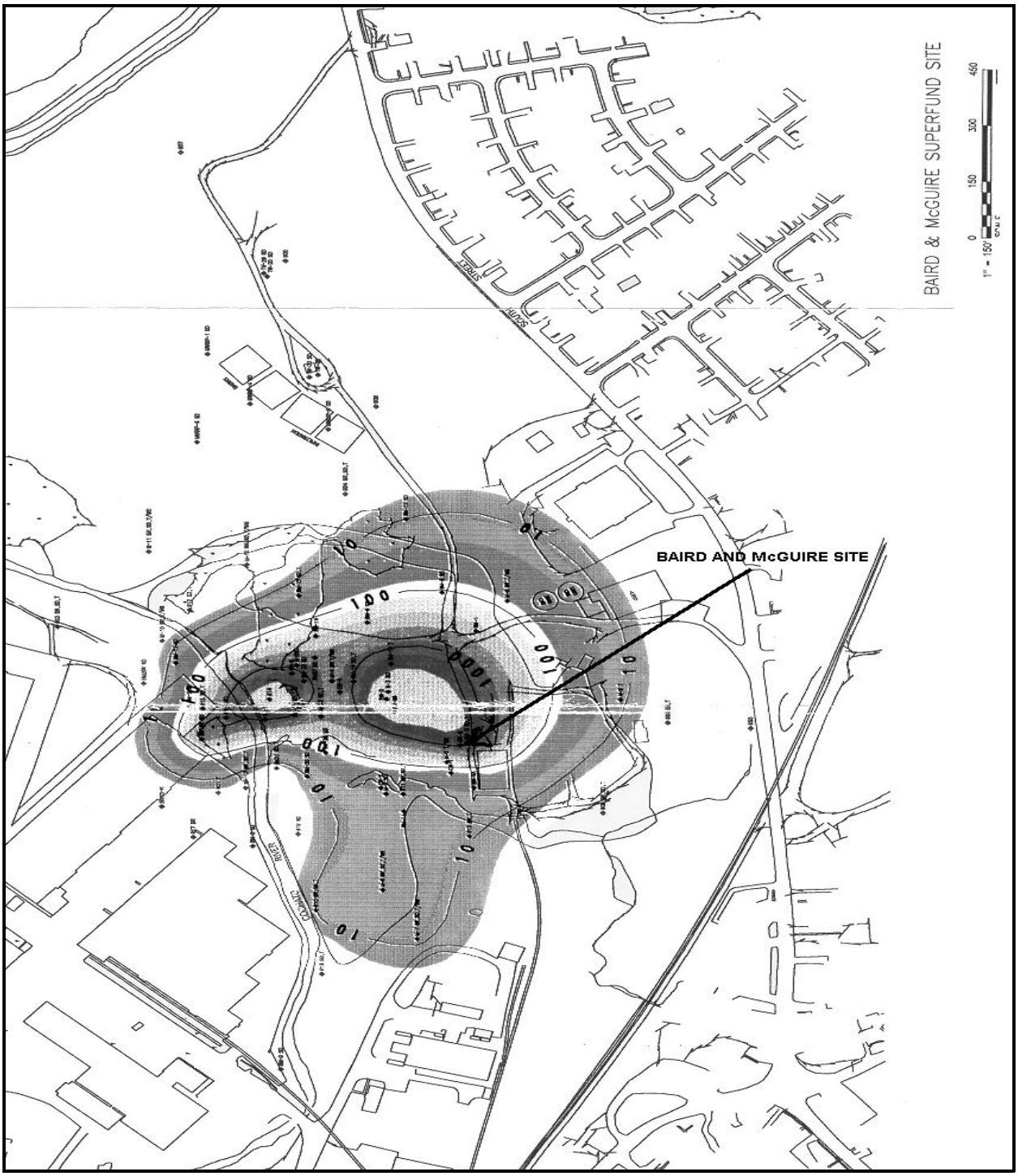

Figure 2. Total Volatile Organic Compounds, in µg/L (1995) (Best Copy Available) [8]

MATRIX DESCRIPTION (CONT.)

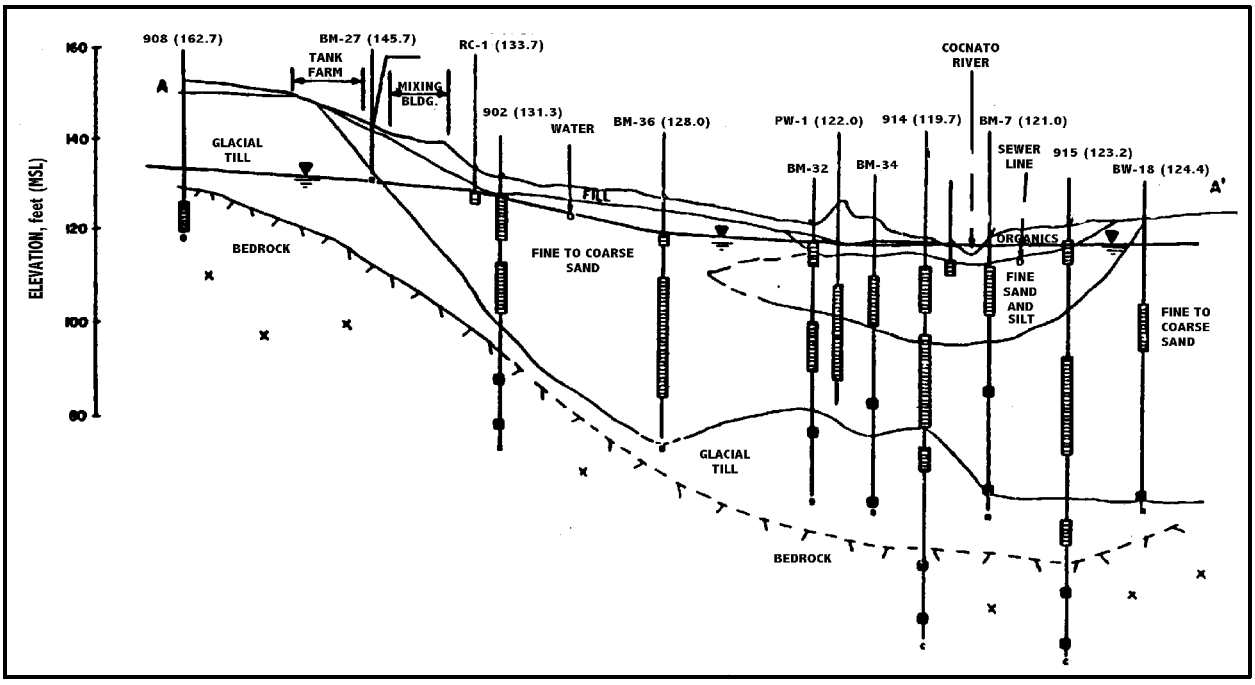

Figure 3. Site Hydrogeology [6]

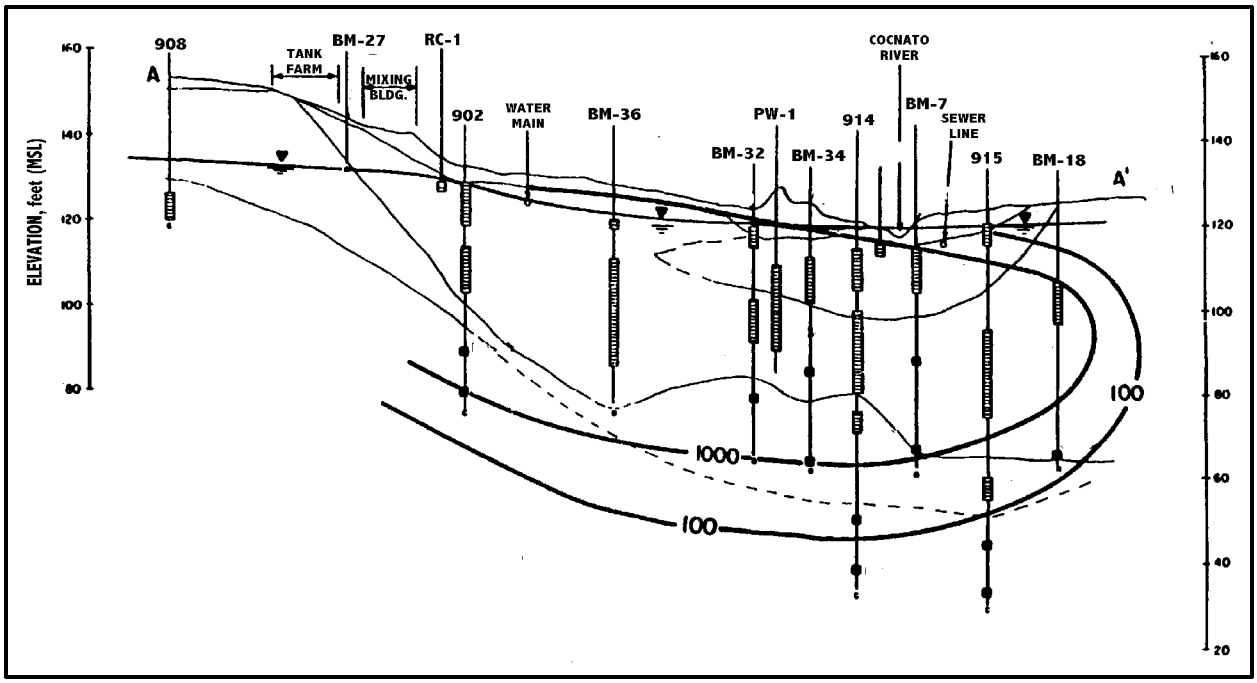

Figure 4. Vertical Extent of Total VOC Plume (µg/L) [6]

MATRIX DESCRIPTION (CONT.)

Tables 1 and 2 include technical aquifer information and technical well data. A discussion of extraction wells is included in the following section.

Table 1. Technical Aquifer Information

Unit Name	Thickness (ft)	Conductivity (ft/day)	Average Velocity (ft/day)	Flow Direction
Unit 1A	10 - 20	3	NA	East[1]
Unit 1B	25 - 50	45	0.3 - 0.7	East[1]
Unit 2	10 - 20	10	0.1 - 1.25	East[1]
Unit 3	>50	0.5	0.3 - 3	East[1]

Source: [6,7]
NA - Not characterized
[1]West side of Cochato River only; flow direction may vary on the east side of the Cochato River.

TREATMENT SYSTEM DESCRIPTION

Primary Treatment Technology

Pump and treat with air stripping and hydroxide precipitation/ferric chloride treatment [3].

Supplemental Treatment Technology

Filtration, carbon adsorption, sludge dewatering [3].

System Description and Operation

Table 2. Technical Well Data

Well Name	Unit Name	Depth (ft)	Design Yield (gal/day)
EW-1	Units 2 and 3	64	28,800
EW-2	Unit 1B	30	43,200
EW-3	Unit 1B	38	43,200
EW-4	Units 2 and 3	84	43,200
EW-5	Unit 1B	32	28,800
EW-6	Unit 1B	30	28,800

Note: Represents initial design conditions. Average system extraction rate is 60 gpm based on the actual volume of water pumped since operations began and a 93% operation rate from April 1993 to December 1995.

Source: [3]

System Description [3,8,9]

- To accommodate soil remediation activities scheduled for 1995, the original groundwater extraction system, installed between 1990 and 1992, was constructed with temporary piping placed in contaminated soils. As discussed earlier, contaminated soils were excavated and incinerated under a separate remedial action. The temporary piping and wells had to be removed when the excavation of contaminated soils began in 1995. The following section describes the system as originally installed and operated through February 1997; however, modifications were made after soil remediation was complete in 1997.
- The extraction system consisted of six wells and associated piping. Four wells were

TREATMENT SYSTEM DESCRIPTION (CONT.)

System Description and Operation (Cont.)

completed in the stratified material (Units 1A and 1B) and two were screened in both the till (Unit 2) and bedrock (Unit 3). The wells were placed in the part of the plume where the highest levels of contaminants were detected. The extraction system design was intended to restore the aquifer and contain the contaminant plume.

- Figure 5 shows a groundwater treatment plant flow diagram. An 8,000-gallon equalization tank is used as the first element of the treatment train to allow for constant flow rate and to remove free floating product. Two stages of hydroxide precipitation are used in the treatment system to allow for maximum metals removal efficiency at different pH levels.

- The original remedial design for the treatment system specified biological treatment of organic contaminants via an activated sludge process. However, because no biological mass existed, the biological treatment process did not achieve effluent limits. Historical analytical data indicate that sufficient organic removal rates are attained without the use of biological treatment [12].

- The activated sludge tanks are currently being used as modified air strippers. Following the air stripping step, rapid sand filtration is used to remove any suspended solids. Filtration is followed by two stages of activated carbon adsorption as a final polishing step.

- Effluent from the treatment system is re-injected into the aquifer through four gravel bed infiltration basins located upgradient of the plume.

- Off-gas generated from each of the unit operations is collected and vented to an on-site fume incinerator (separate from the soil incinerator), which destroys organics by thermal oxidation at a temperature of 1,800°F. The fume incinerator is soon to be replaced by vapor phase carbon.

- Solid waste including precipitate and activated carbon from the treatment system is disposed of off site.

- A total of 49 monitoring wells were installed in units 1B, 2, and 3 to evaluate contaminant concentration levels from 1993 to 1995. During soil excavation activities from 1995 to 1997, nearly half of the monitoring wells were damaged and not usable. The monitoring wells were replaced in 1997.

System Operation [8,9,10]

- From April 1993 to June 1995, the extraction system was operated using all six wells. After soil excavation began in June 1995, only one well, on average, was operating. Extraction wells were taken off line to allow for excavation activities, and because of poor well yield. There was no change to the treatment system until early 1997 when several upgrades were completed. Since startup, the treatment system has operated at an average extraction rate of 60 gpm, and has been unable to operate at its design rate of 150 to 200 gpm because of several problems, including undersized pumps and sludge thickener loading rates. Pumps were replaced and a larger sludge thickener installed in early 1997. These changes have enabled the treatment system to operate at its design rate since then.

- According to site engineers, at the time excavation and incineration activities began, the groundwater extraction system had not provided the required extraction rate to achieve hydraulic containment of the plume. In 1995, new well locations and screen intervals were chosen to increase the extraction rate. Other activities that were planned included replacing three of the extraction wells, installing two additional extraction wells, and retrofitting two existing extraction wells with collection equipment to enhance LNAPL removal. A groundwater model was used to optimize the extraction system. Extraction system upgrades should be completed in late 1997 when the P&T system is scheduled to resume full-scale operation.

TREATMENT SYSTEM DESCRIPTION (CONT.)

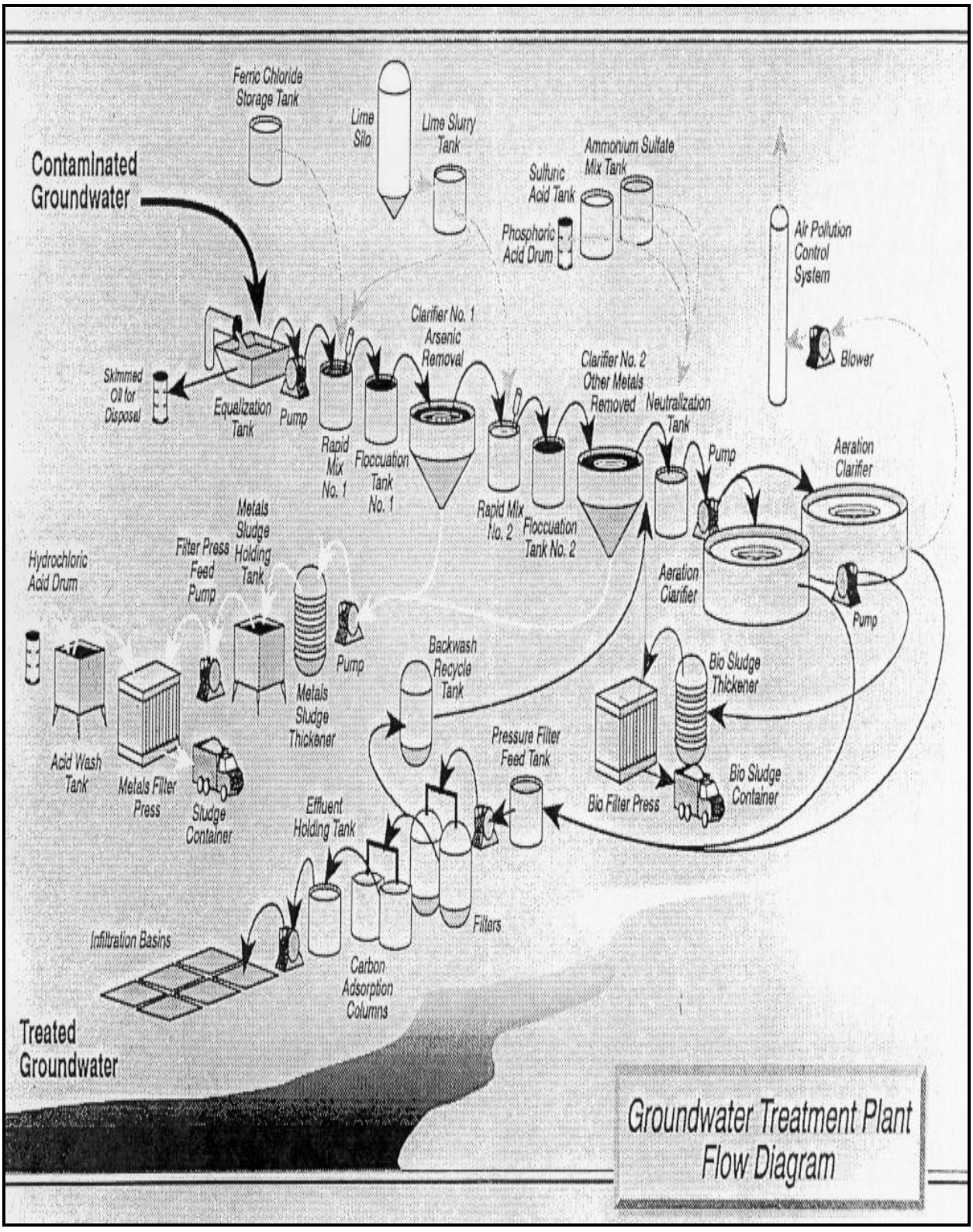

Figure 5. Groundwater Treatment Plant Flow Diagram [12]

TREATMENT SYSTEM DESCRIPTION (CONT.)

System Description and Operation (Cont.)

- Quantity of groundwater pumped from aquifer in gallons:

Year	Total Volume Pumped (gallons)	Unit Name
1993	18 million	1B,2,3
1994	34 million	1B,2,3
1995	28 million	1B,2,3

- As of February 1997, the treatment system has been 93% operational. Down time has been primarily due to problems with computer control instrumentation and lime buildup in feed lines.

- Excavation and on-site incineration of soils took place from 1995 to 1997. Wastewater from dewatering and incineration blowdown operations was pumped to the groundwater treatment system during this time. Since January 1996, the majority of flow to the treatment system has come from these operations.

- The wastewater generated from soil dewatering and incineration activities was estimated to be 100 gpm. The treatment system was required by contract to handle this additional wastewater flow and would reduce the volume of groundwater being sent from extraction wells if needed. However, this was not required because the groundwater extraction rate was approximately 50 gpm at that time.

- Once excavation and incineration activities began, piping and extraction wells were removed and replaced as contaminated soils were excavated and clean fill was replaced. During this time, the average extraction rate was approximately 25 gpm.

- The carbon units have been changed out approximately every two months or every eight million gallons treated. Approximately 115,000 pounds of spent carbon were regenerated or disposed of from 1993 until 1997.

- During soils excavation activities, the excavating contractor accidentally damaged or destroyed over 25 of the 49 monitoring wells. As a result, the site engineer has not been able to adequately monitor the contaminant plume during soil remediation activities. The excavation contractor will replace the damaged wells after soil remediation activities are complete.

- The long-term groundwater monitoring procedure approved by EPA stated that 20 perimeter wells would be monitored on a quarterly basis. After two consecutive sampling events from a well where no contaminants are detected, a different well nearer to the source area is chosen for the next sampling event.

TREATMENT SYSTEM DESCRIPTION (CONT.)

Operating Parameters Affecting Treatment Cost or Performance

Table 3 shows operating parameters affecting cost or performance for this technology.

Table 3: Performance Parameters

Parameter	Value	
Average Extraction Rate	60 gpm	
Performance Standard (effluent) and Remedial Goal (aquifer) (µg/L)	Arsenic	0.05 µg/L
	Lead	0.05 µg/L
	Benzene	5 µg/L
	Toluene	2,000 µg/L
	Ethylbenzene	680 µg/L
	Xylene	440 µg/L
	2,4-dimethyl phenol	2.12 µg/L
	Naphthalene	0.62 µg/L
	Acenapthene	0.52 µg/L
	Dieldrin	0.000071 µg/L
	Chlordane	0.00046 µg/L

Source: [5]

Timeline

Table 4 presents a timeline for this remedial project.

Table 4: Project Timeline

Start Date	End Date	Activity
9/86	---	Date of ROD for this OU
5/87	---	Remedial design accepted
9/87	6/89	Design document prepared by Metcalf & Eddy
5/90	1/93	Construction of the groundwater treatment system
1/93	---	Groundwater treatment plant begins operations and compliance monitoring begins
6/95	5/97	Incineration activities performed
2/97	---	Groundwater treatment plant modified to increase capacity to 200 gpm
8/97	---	Anticipated date for restart of P&T full-scale operation

Source: [3, 8, 9, 10]

TREATMENT SYSTEM PERFORMANCE

Cleanup Goals/Standards

Cleanup goals were established during the design phase to be maximum contaminant levels (MCL), as defined by the Primary Drinking Water Standards and the State of Massachusetts Drinking Water Quality Criteria. Specific criteria are included in Table 3. These goals must be met in all monitoring wells located on site [5].

Additional Information on Goals

In the cases where no MCL is available, the applicable regulation is EPA Ambient Water Quality Criteria for Freshwater Aquatic Organisms and Criteria for Human Consumption. Of the pollutants listed in Table 3, only arsenic, lead, and BTEX compounds have MCLs established [5].

TREATMENT SYSTEM PERFORMANCE (CONT.)

Treatment Performance Goals [3,5]

- To remediate the contaminated aquifer within a reasonable time to prevent present or future impacts to groundwater drinking water supplies.
- To protect the Cochato River from future contaminant migration by establishing hydraulic containment to capture the contaminant plume.

Performance Data Assessment [8,9,10,11,12]

For the purposes of this report, total contaminants refers to the broad classes of VOC and SVOC compounds detected at this site.

- During the first three years of operation, the P&T system reduced average VOC and SVOC concentration levels. The maximum concentration of contaminants detected in individual wells after three years of system operation were total SVOCs (7,967 µg/L) and total VOCs (11,870 µg/L).
- Figure 6 illustrates changes in average contaminant concentrations in the groundwater from 1994 to 1995. The data in Figure 6 show an overall decline of 16% (VOC) and 48% (SVOC) in average groundwater concentration from 1994 through 1995. However, contaminant concentrations in some individual wells did not decline over this period, and contaminant concentrations have not been reduced to below treatment goals.
- Contaminants have been detected in downgradient monitoring wells as noted in the 1995 Annual Report. On the basis of this information, plume containment has not been achieved. A 1995 groundwater study made recommendations for achieving plume containment.
- Groundwater models run by site engineers estimated that an extraction rate of approximately 150 gpm is required for plume containment. However, the treatment plant was not able to operate at its design rate of 150 to 200 gpm due to undersized pumps and sludge thickener. The extraction network also could not achieve the design extraction rate of 150 gpm due to well placement, clogging problems, and the shut-down of wells for soil remediation.
- As shown in Figure 7, the P&T system removed approximately 2,100 pounds of organic contaminant mass from the groundwater as of December 1995. Mass removed from metals precipitation units was not estimated for this report.
- Figure 7 presents the mass removal of contaminants through the treatment system from June 1994 to December 1995. A total of 80 million gallons of groundwater have been treated. The daily average treatment rate was 60 gpm as determined by the on-site contractor.
- The contaminant removal rate has fluctuated over the 1994-1995 operating period. The data presented in Figure 7 show a reduction in mass flux rate from 1994 to 1995. This decrease is due primarily to a decrease in flow rate to the treatment system. Available data indicate that influent concentrations have remained relatively constant.
- Several modifications are planned for groundwater remediation after the soils remediation activities are complete. Implementation of these modifications has reportedly begun. The first new extraction well is scheduled to be on-line by April 1998. An additional extraction well plus two LNAPL extraction wells are scheduled for later this year.

TREATMENT SYSTEM PERFORMANCE (CONT.)

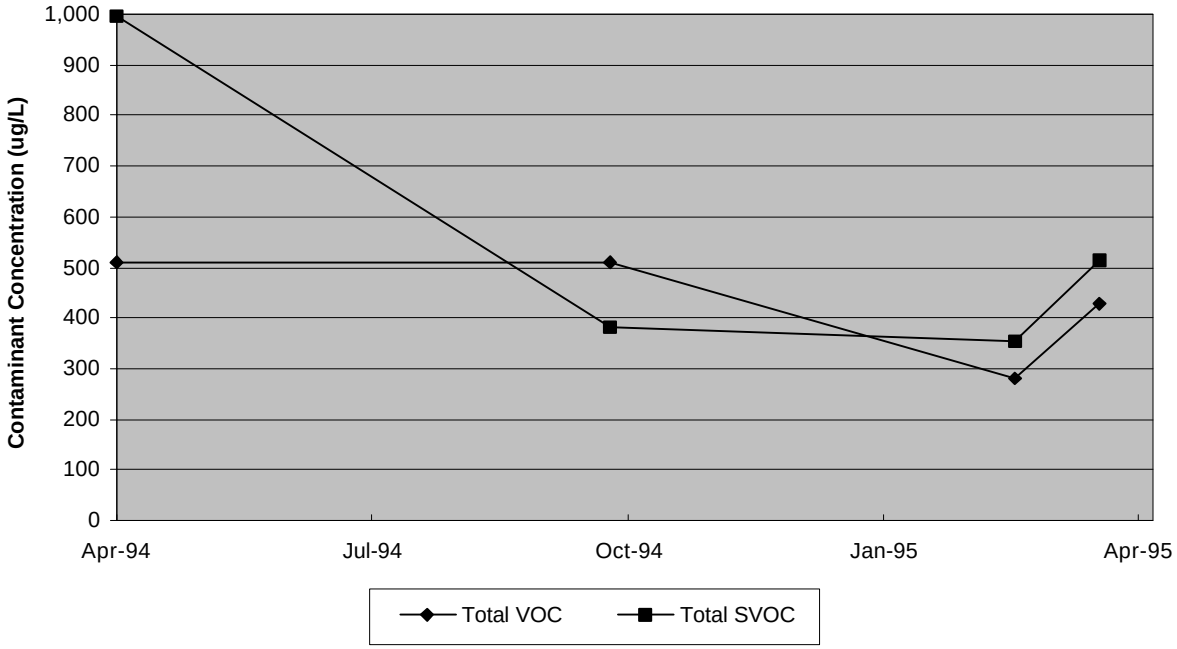

Figure 6. Average Contaminant Concentrations (1994-1995)

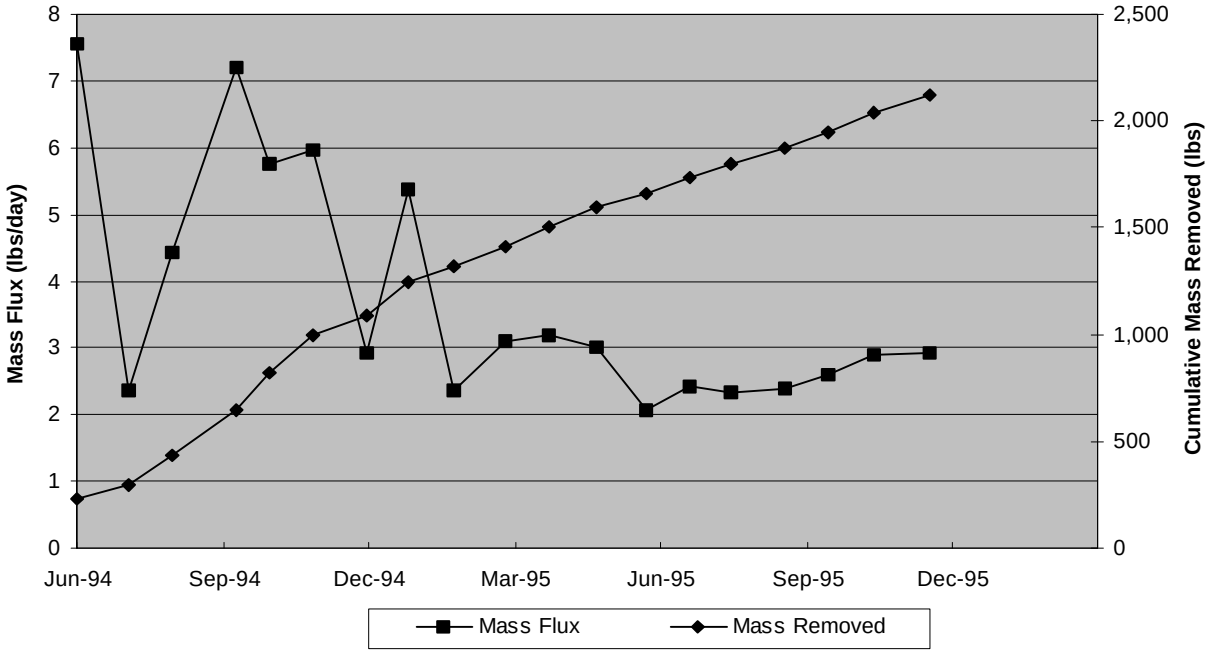

Figure 7. Mass Flux Rate and Cumulative Contaminant Removal (1994-1996)

TREATMENT SYSTEM PERFORMANCE (CONT.)

Performance Data Completeness

- Performance sampling for the treatment system is completed on a weekly basis. Influent concentration, effluent concentration, flow, chemical usage, and sludge production data are available in monthly reports.
- Monthly reports for 1994 and 1995 were used for mass flux analyses performed in this report. No data were available for performance evaluation from April 1993 to June 1994.
- Contaminant mass removal was determined using analytical results from weekly influent and effluent sampling, along with average flow rate data. One weekly event per month was used for this calculation.
- Concentration data for the six extraction wells are available for April 1994, October 1994, March 1995 and April 1995 sampling rounds only. These data were used to compute the average groundwater concentration presented in Figure 6. A geometric mean was used to estimate average groundwater concentrations and provide a trend for the entire plume.

Performance Data Quality

The QA/QC program used throughout the remedial action met the EPA and the State of Massachusetts requirements. All monitoring was performed using EPA-approved methods, and the vendor did not note any exceptions to the QA/QC protocols.

TREATMENT SYSTEM COST

Procurement Process

The U.S. EPA is the lead agency for this site. The U.S. Army Corps of Engineers (USACE), N.E. Division, has been contracted to provide operations and maintenance of this site for the first ten years of operation. The New England Division of the USACE is managing all on-site activities. Metcalf & Eddy Services was awarded the contract for treatment system design and subsequently subcontracted Barletta Engineering to construct the treatment system. Metcalf & Eddy Services has been contracted to provide operation and maintenance services for the groundwater treatment system.

Cost Analysis

- All costs for remedial activities at this site were shared by the U.S. EPA and Massachusetts DEQE. The costs presented are for the groundwater pump and treat system only. No costs for the soil excavation and incineration, performed under a separate remedial action, are included.

TREATMENT SYSTEM COST (CONT.)

Capital Costs [4,9]

Remedial Construction	
Administrative, Mobilization, and Demobilization	$3,490,595
Monitoring Wells and Sampling	$230,222
Site Work	$159,016
Ground Water Extraction/ Infiltration	$633,884
Treatment System	$9,274,652
Corps Management Costs	$1,169,292
Total Remedial Construction	**$14,957,661**

Operating Costs [4,9]

Operation and Maintenance	$4,902,878
Chemicals	$61,016
Metal Sludge Disposal	$568,670
Biological Sludge Disposal	$30,259
Carbon Regeneration/Purchase	$175,044
Utilities	$685,351
Laboratory Supplies	$772,211
Site Security	$408,159
Lab Services	$140,076
Equipment for collection and storage of LNAPL	$25,110
Total Cumulative Operating Expenses from April 1993 to February 1997	**$7,768,780**

Other Costs [4,9]

Remedial Design	
Remedial Design	$3,364,222
State Oversight	$39,911

Cost Data Quality

Actual capital and operations and maintenance cost data are available from the Army Corps of Engineers contact for this site.

OBSERVATIONS AND LESSONS LEARNED

- Total cost for the P&T system at the BMI site was approximately $22,726,000 ($14,958,000 in capital costs and $7,768,000 in cumulative operation and maintenance costs). The unit costs for this clean-up are calculated to be $284 per 1,000 gallons of groundwater treated, and $10,822 per pound of organic contaminant removed.
- According to the site contact, substantial time and money were spent during the first year of operation in an attempt to acclimate biological organisms to the wastewater stream [4].
- Operating costs are high due to high analytical costs for the large number of contaminants and the cost for an operator to be on-site 24 hrs per day.
- The management plan to have concurrent groundwater and soil remediation activities resulted in high construction costs and logistics problems. A temporary groundwater extraction system was installed and then removed two years later when soil excavation began. In addition, monitoring wells installed across the site made it difficult to operate heavy machinery without damaging well heads. Ultimately, over 25

OBSERVATIONS AND LESSONS LEARNED (CONT.)

monitoring wells were accidentally damaged or destroyed during the soil excavation activities. Replacement costs for these wells will be paid by the excavation contractor.

- In early 1997, plant upgrades such as pump replacement and sludge thickener unit replacement were required to achieve design capacity of 200 gpm. Upgrades were completed at a cost of $100,000 which is included in the $14.9 million [9].

- The treatment system performance data indicate that over 2,100 pounds of organic contaminants were removed from the groundwater as of December 1995. The P&T system has not met the cleanup goals, and maximum VOC and SVOC concentrations in extraction wells remain in excess of 11,000 and 7,000 µg/L, respectively.

- LNAPL material has been observed in two on-site wells, indicating the presence of a subsurface source of pollutants. Fluctuations in contaminant concentration levels were noted within several wells placed near the center of the plume. These fluctuations are also indicative of possible subsurface source zones contributing to the dissolved groundwater plume.

- During excavation and incineration activities, extraction wells and associated piping were replaced. These activities disrupted the groundwater extraction program and may have resulted in further off-site plume migration. Plume migration cannot be assessed at this time because of the interruption of the groundwater monitoring program.

- From 1993 to 1996, the overall extraction rate was 60 gpm, which is less than the design extraction rate of 150 to 200 gpm. Modifications to the extraction system will be made in 1997. According to the site engineer, the modifications will include repairing three wells and adding two new wells. The 1995 annual groundwater study and a calibrated groundwater model of the site were used to locate the two additional wells. Several wells will also be equipped to remove LNAPL material [9].

- The 1995 annual groundwater study included an optimization section which, with the aid of the groundwater model, made recommendations for enhancing the P&T system performance. Most recommendations were targeted at improving plume containment and increasing mass flux to the treatment system.

REFERENCES

1. Final Work Plan Focused Feasibility Study, Ebasco Services, February 1988.
2. Water Supply Feasibility Study, Ebasco Services, May 1990.
3. Remedial Action Report, Baird and McGuire Superfund Site, Holbrook, MA, Operable Unit #1, Groundwater Treatment Facility, March 1993.
4. Correspondence with Mr. Chet Janowski, Remedial Project Manager, U.S. EPA Region I, April 10, 1997.
5. Superfund Record of Decision, U.S. EPA, September 1986.
6. Remedial Investigation Report, Baird & McGuire Site, Holbrook, MA. GHR Engineering Associates, Inc., May 1985.
7. Remedial Investigation Addendum Report, Baird & McGuire Site, Holbrook, MA. GHR Engineering Associates, Inc., June 1986.
8. Evaluation of Extraction System Performance at the Baird & McGuire Superfund Site. Metcalf & Eddy Services, July 1995.
9. Correspondence with Mr. Chris Zevitas, Site Engineer, U.S. Army Corps of Engineering (USACE), April 14, 1997.
10. Monthly Process Summaries, 1994-1996, USACE.
11. Dense Nonaqueous Phase Liquids, Huling, S.G., and J.W. Weaver, U.S. EPA, March 1991.
12. Monthly Process Summary, February 1997.

Analysis Preparation

This case study was prepared for the U.S. Environmental Protection Agency's Office of Solid Waste and Emergency Response, Technology Innovation Office. Assistance was provided by Eastern Research Group, Inc. and Tetra Tech EM Inc. under EPA Contract No. 68-W4-0004.

ATTACHMENT A

*Detected Compounds Listed in the ROD**

1,1-Dichloroethylene	Parius
1,2-Dichloroethane	Ethylbenzene
Aldrin	Fluoranthene
Arsenic	Lead
Benzene	Silver
Benzidine	Toluene
Benzo(a)pyrene	Xylenes (TOT)
Beryllium	Zinc
BHC-Alpha	Dibenzofuran
BHC-Beta	Total Other PAHs:
BHC-Delta (Tech)	2-Methylnaphthalene
BHC-Gamma	Acenaphthene
Cadmium	Acenaphthylene
Chlordane	Anthracene
Chloroform	Benzo(a)anthracene
Dieldrin	Benzo(b)fluoranthene
Heptachlor	Benzo(ghi)perylene
Heptachlor Epoxide	Benzo(k)fluoranthene
Nickel	Chrysene
Tetrachloroethylene	Dibenzo(a,h)anthracene
Trichloroethylene	Fluorene
Vinyl Chloride	Ideno(1,2,3-CD)pyrene
1,2-*trans*-dichloroethylene	Naphthalene
1,3-*trans*-dichloropropylene	Phenanthrene
2-Butanone	Pyrene

*Individual pollutant levels were not provided.

This Page Intentionally Left Blank